CSN Children's Safety Network

EDC Education Development Center

March 27, 2019

Protecting Child Passengers, Now and Into the Future

Funding Sponsor

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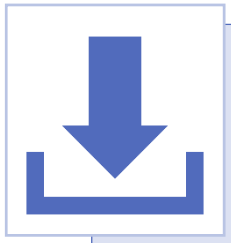

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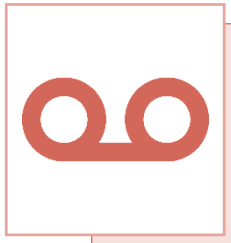


This session is being recorded

Presenters

Richard Hamburg

Joyce Pressley

Aditya Belwadi

Protecting Child Passengers, Now and Into the Future

Joyce Pressley, PhD, MPH

Columbia University

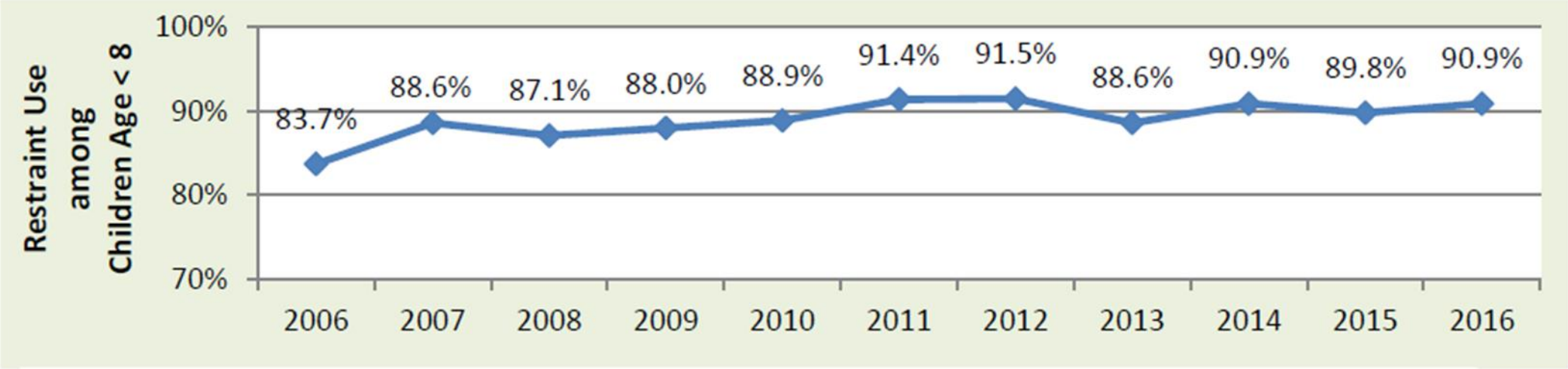
Wednesday, March 27, 2019
2:00 - 3:00 pm ET

Current and Emerging Issues in Child Occupant Safety

- All 50 states, DC and all U.S. territories have laws requiring children to be restrained while riding in MVs
  - V**ariability in ages covered** across states
  - Uneven enforcement and penalties for failure to properly seat and restrain
  - Many are **secondary law**s which require another offense before driver can be ticketed for improper transport of a child passenger
  - Growth in number of children being transported who fall into one of the **many restraint exemptions**/loop holes
    - Vehicles for hire
    - Gaps in our surveillance systems that fail to capture when a vehicle is operating in “for hire” mode

Current and Emerging Issues in Child Occupant Safety

- NHTSA surveys document child restraint use hovering around 90%
  - Booster seats use by 4-7 yr olds hovering around 40%
  - Nearly **one-third of deaths in this age group are unrestrained**
  - Improvements have stagnated



1. National Center for Statistics and Analysis. (2018, April, Revised). Children: 2016 data. (Traffic Safety Facts. Report No. DOT HS 812 491). Washington, DC: National Highway Traffic Safety Administration.
2. Li, R., Pickrell, T. M. (2018, May, Revised). Occupant restraint use in 2016: Results from the NOPUS controlled intersection study (Report No. DOT HS 812 463). Washington, DC: National Highway Traffic Safety Administration.

Current and Emerging Issues in Child Occupant Safety

- Car seats reduce risk of fatal injury[1]
  - 71% in infants
  - 54% in toddlers
- Restraint use is **lower in older children**
- Large **disparitie**s in child occupant mortality
  - Large historical **race and ethnic disparities** are being maintained or, in some cases, widening
  - Occupant mortality is 2-3 times **higher in non-metro** areas
- Large proportion of MV traffic deaths in these age groups are "unspecified"

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[1]Credits: Laura Dunn, NHTSA, DOT Reports HS 812 491, HS 812 463

Current and Emerging Issues in Child Occupant Safety

- Shifting trends in where parents and child caregivers obtain their information
  - Need for further research in message content and communication modes
- Current failure of **impaired drivers** to transport children properly restrained and rear-seated
  - Opioid crisis
  - Growth in number of states with legalization of non-medical marijuana
  - Gaps in drug and alcohol testing across states
  - Increased risk associated with polysubstance impairment

Current and Emerging Issues in Child Occupant Safety

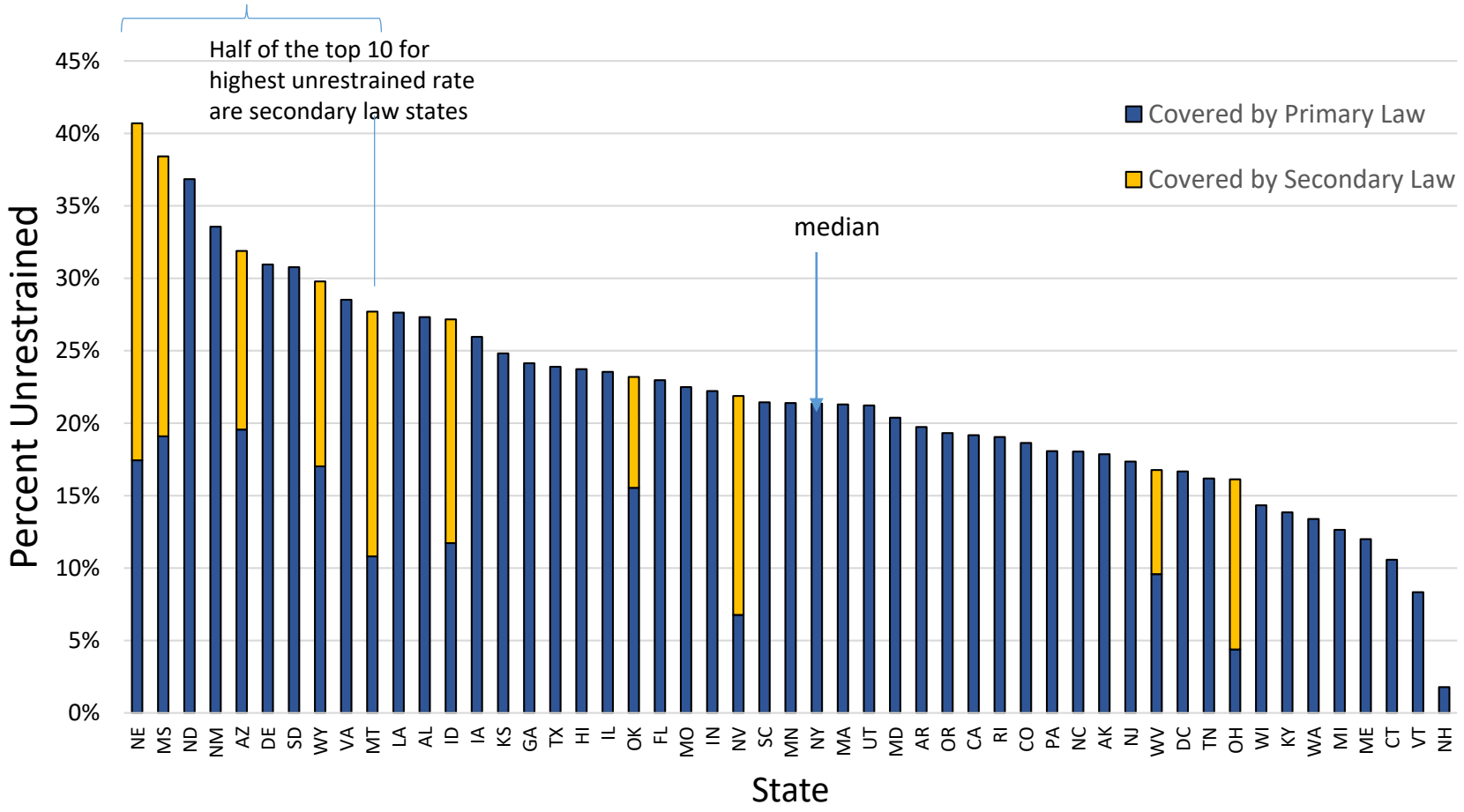
- Behavioral impact of equipment/terminology harmonization
  - Seat-vehicle compatibility, ease of use and behavioral responses
- Advances in **vehicles with various levels of autonomy**
  - Initial uptake predicted to be higher in vehicles-for-hire where restraint laws are lacking in children
  - Impact on impairment of occupants and proper restraint of children
  - Seating configurations and biomechanics of crash testing

State Level Variations in Restraint Use and Mortality in Pediatric Occupants Involved in a Fatal Collision

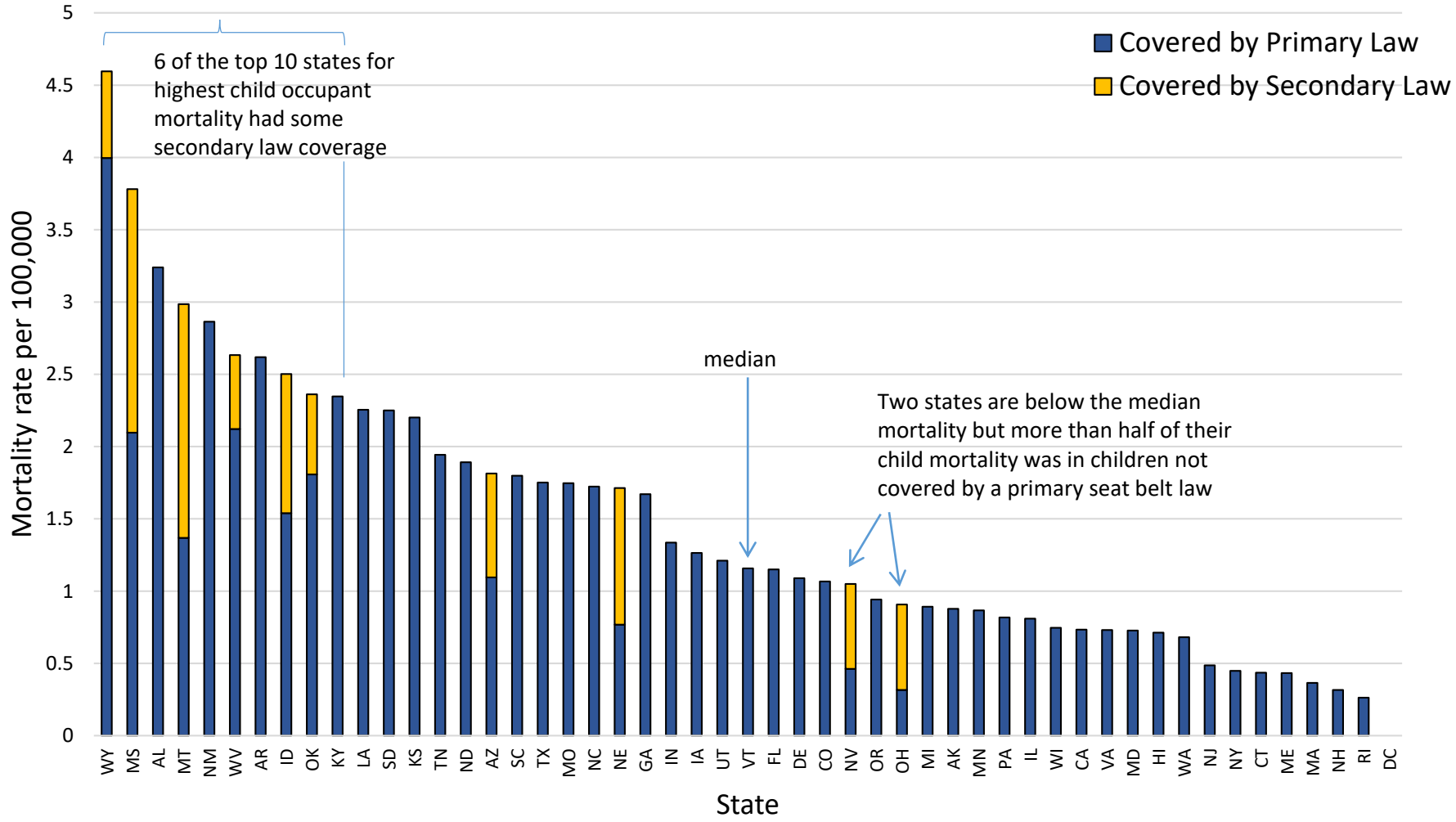
State-level Variation in Pediatric Occupant Mortality by Primary and Secondary Law Coverage

- Between 2010-2014, 21,727 pediatric occupants aged 0-12 yrs were involved in a fatal motor vehicle crash resulting in 3,297 pediatric deaths (15.2%)
- Annual MV occupant mortality rates varied across states
  - Ranging from 0.3 in Rhode Island to 4.6 per 100,000 in Wyoming
- More than half of the 10 states with the highest child MV mortality rates had gaps in pediatric restraint laws

Percent Unrestrained for Ages 0-12 Years Involved in a Fatal MV Collision by Primary and Secondary Law Coverage

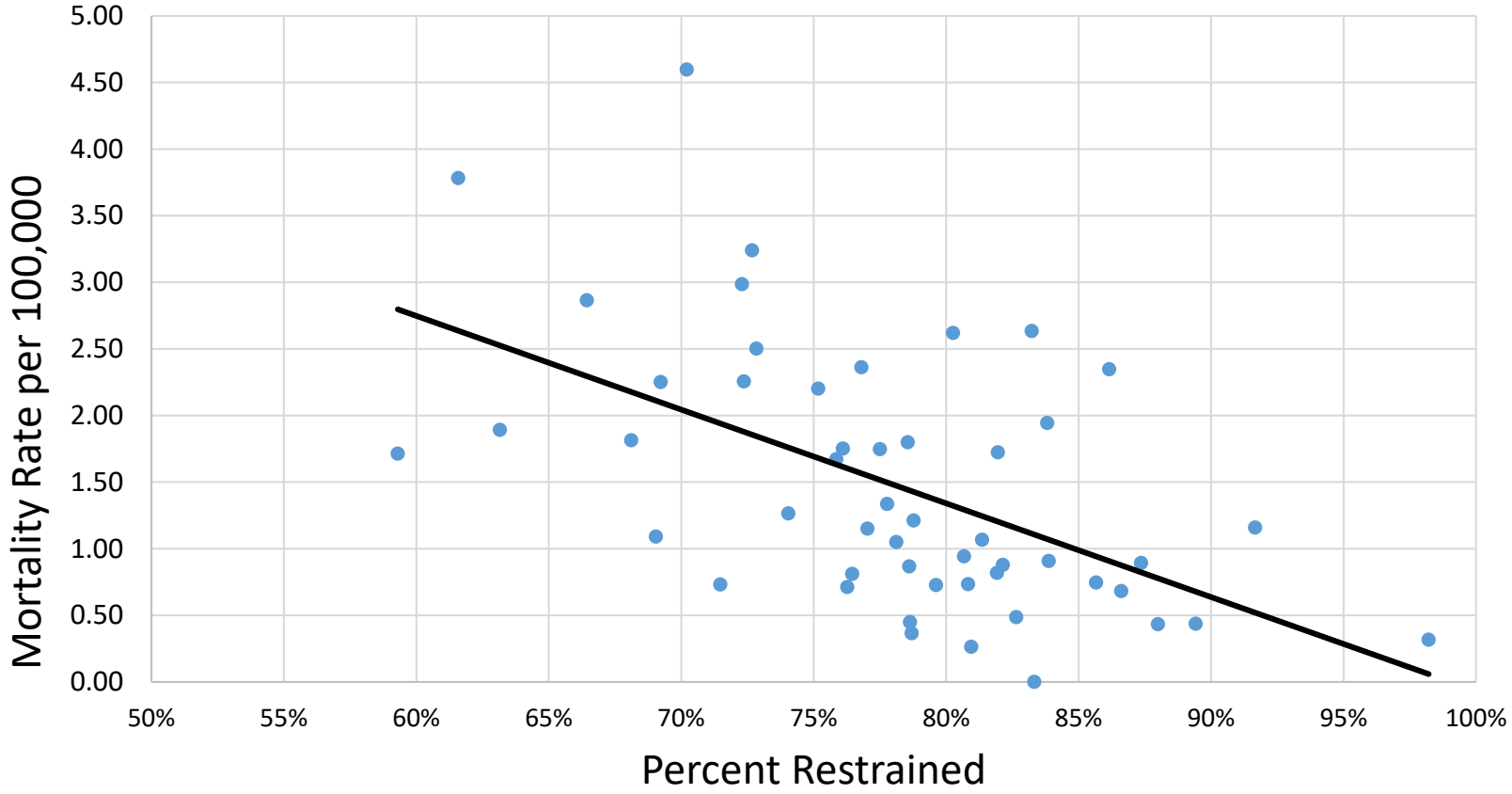


Occupant Mortality (per 100,000) for Ages 0-12 Years by Primary and Secondary Law Coverage

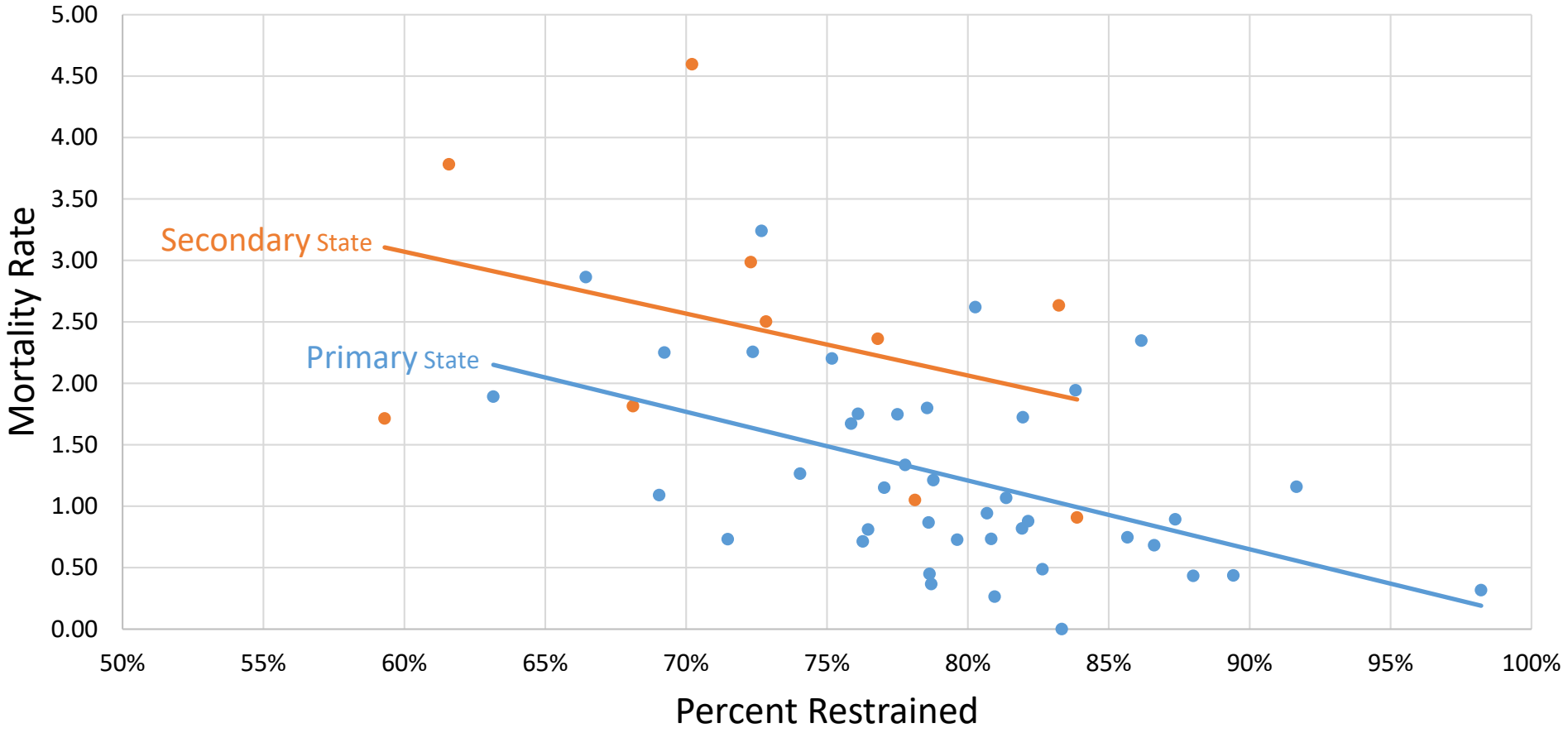


AZ covers age 0-7; ID age 0-6; MS age 0-6; MT age 0-5; NE age 0-5; NV age 0-5; OH age 0-3; OK 0-8; WY age 0-8
WV covers age 0-7, transitioned to primary law covering all children in 2013

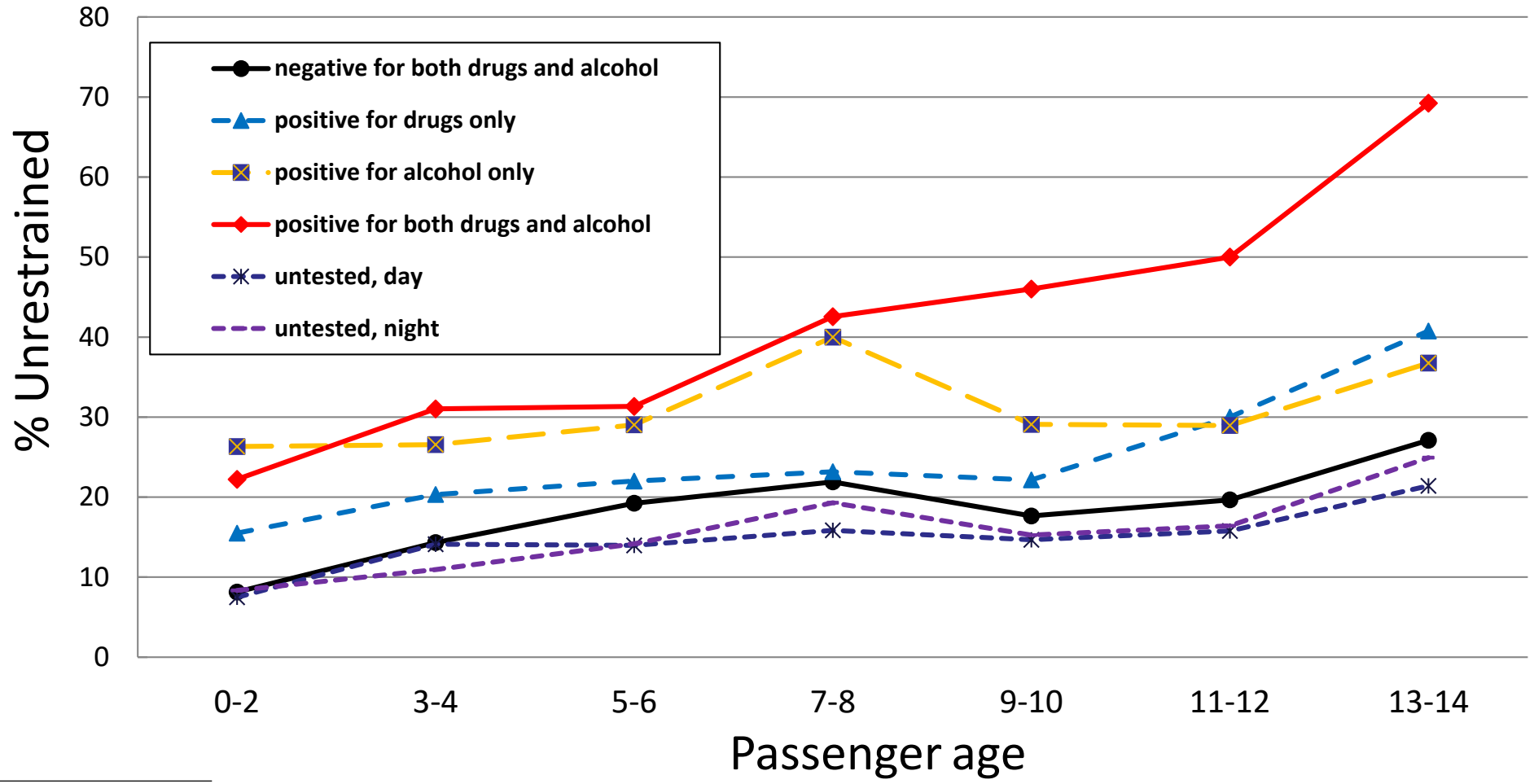
Inverse Relationship Between Percent Restrained and Mortality Rate (per 100,000) for Ages 0-12 Years



Inverse Relationship Between Percent Restrained and Mortality Rate by Primary or Secondary State Law for Ages 0-12 Years

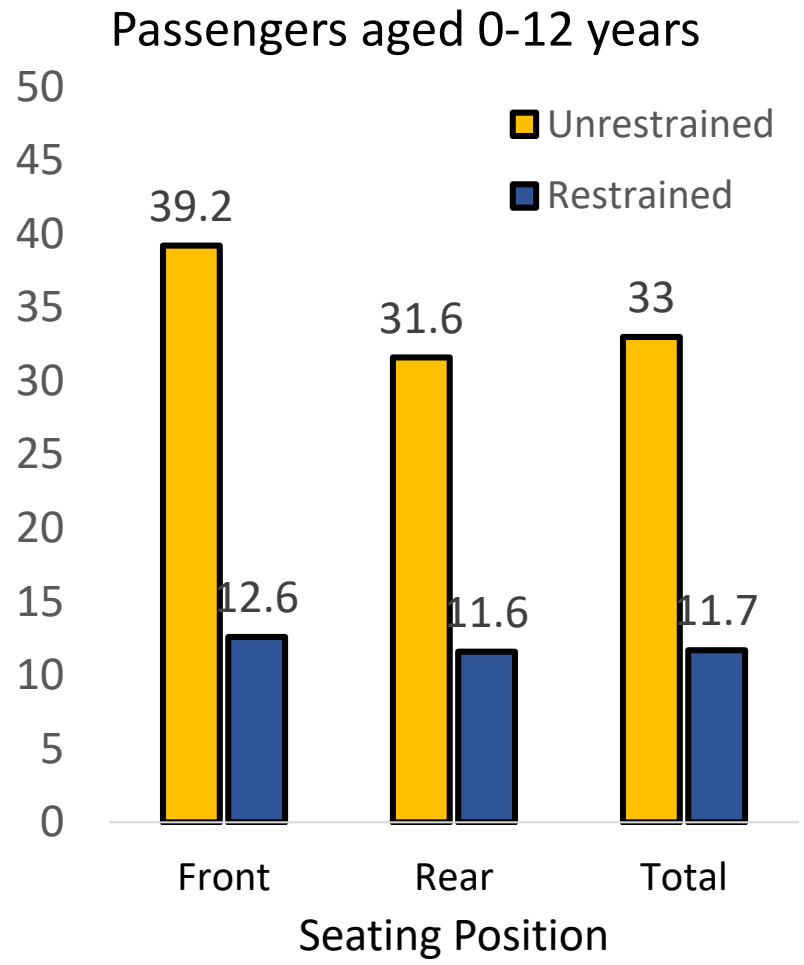


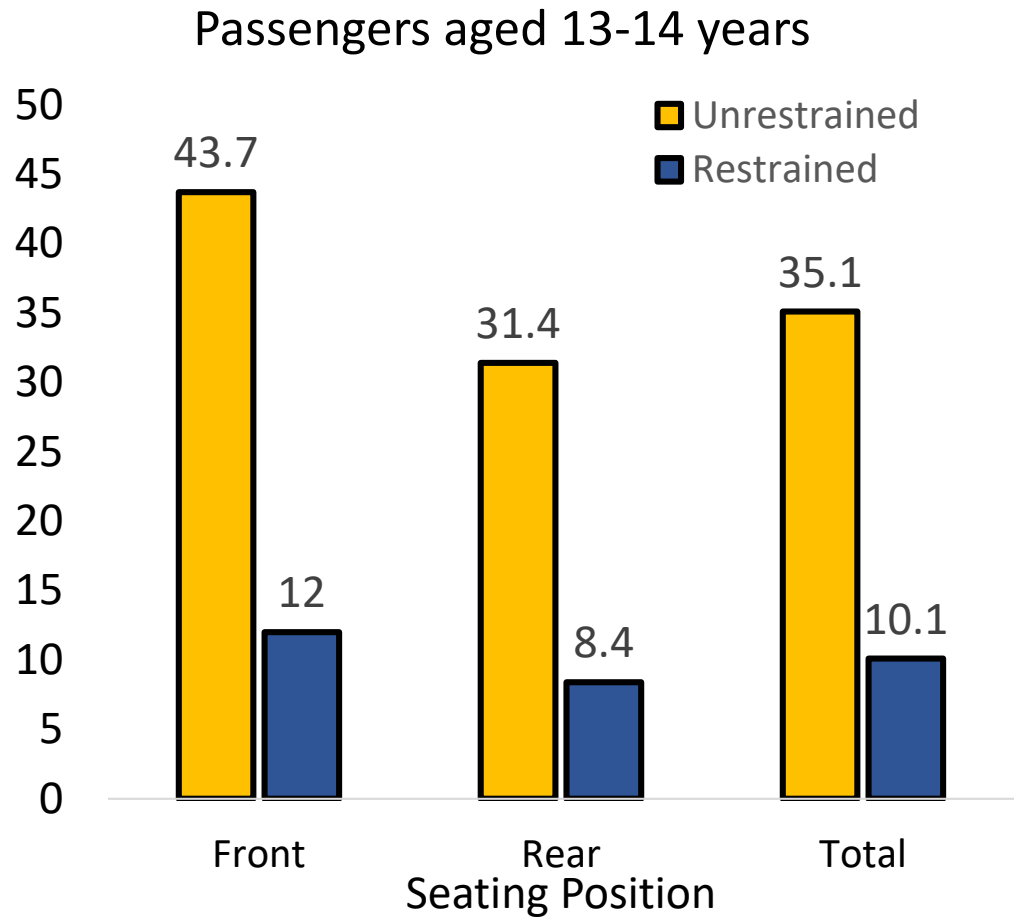
Percent Unrestrained U.S. Passengers by Passenger Age and Driver Drug and Alcohol Status, FARS 2010-2013



Huang, Liu and Pressley, Pediatrics 2016

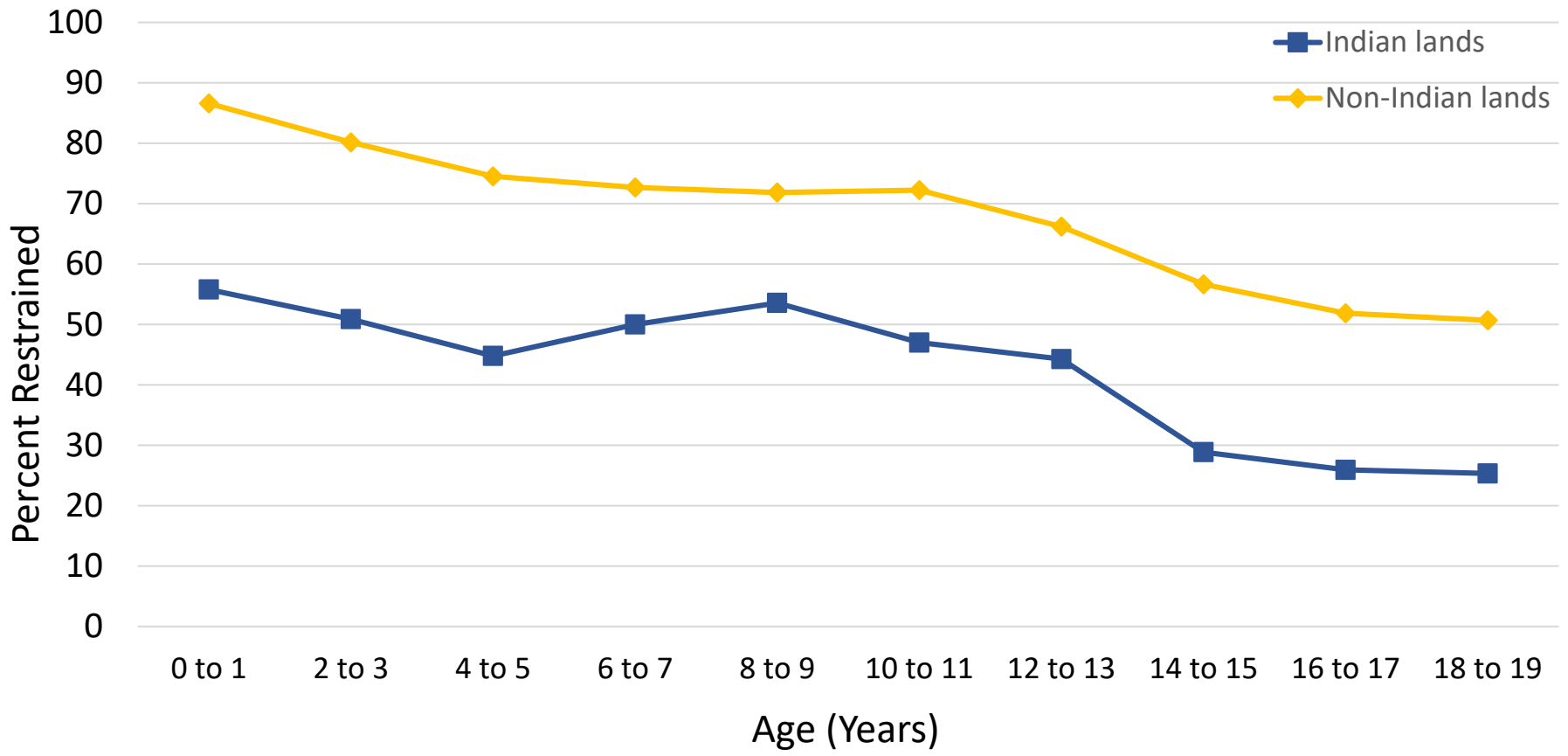
Front vs. Rear-Seated Percent Mortality of Child Passengers Involved in a Fatal Crash by Age Group and Seating Position





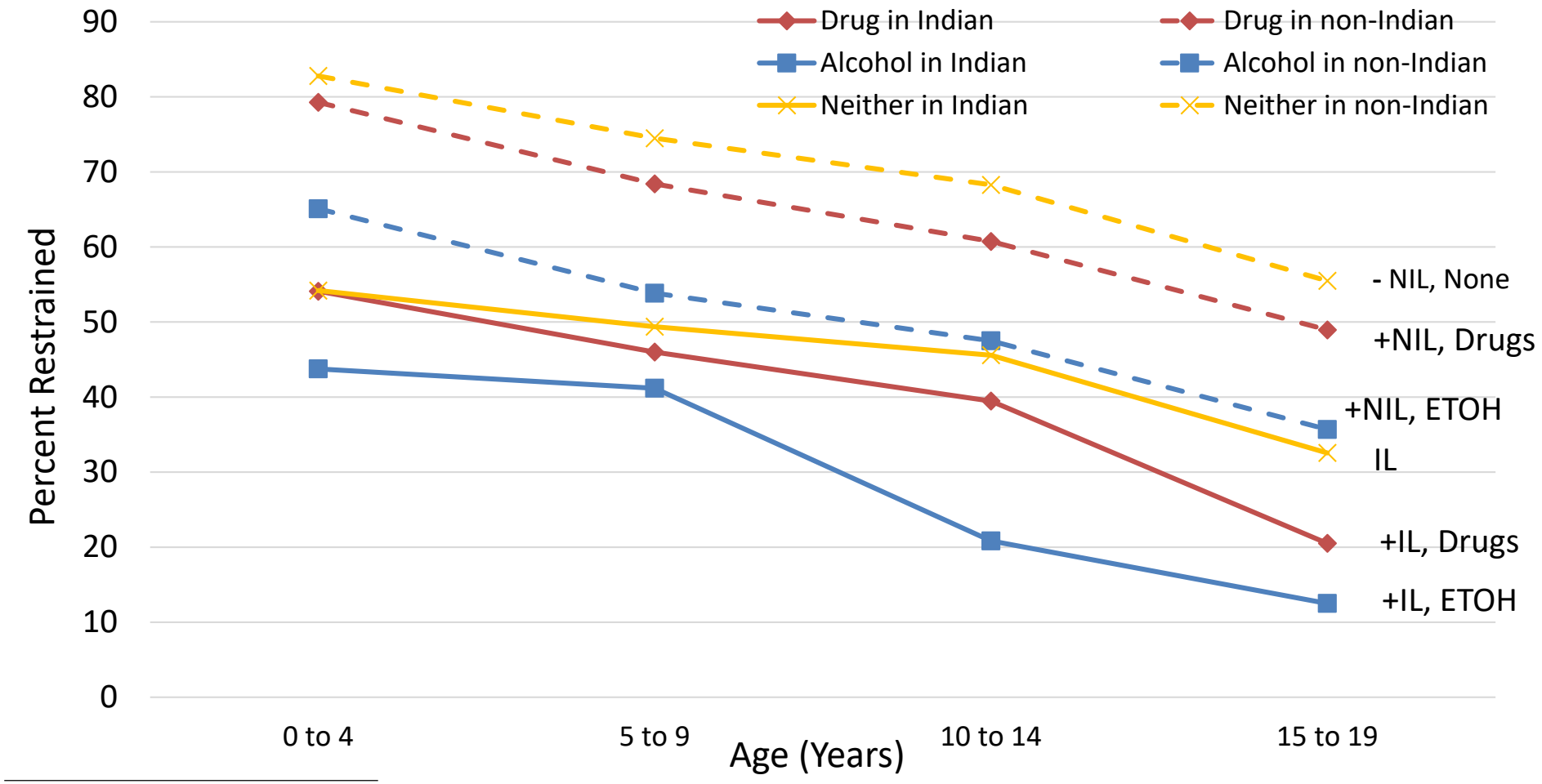
Huang, Liu and Pressley, Pediatrics 2016

Restraint Use in Pediatric Population by Age on Federally Designated Indian lands vs. Non-Indian lands, FARS 2000-2014



Oh, SA, Liu C, Pressley JC. Fatal Pediatric Motor Vehicle Crashes on U.S. Native American Indian Lands Compared to Adjacent Non-Indian Lands: Restraint Use and Injury by Driver, Vehicle, Roadway and Crash Characteristics. International Journal of Environmental Research and Public Health 2017; doi:10.3390/ijerph14111287

Driver Drug and Alcohol Status by Passenger Restraint Status -- Fatal Collisions on Federal Designated Indian lands (IL) Compared to Adjacent States (NIL)



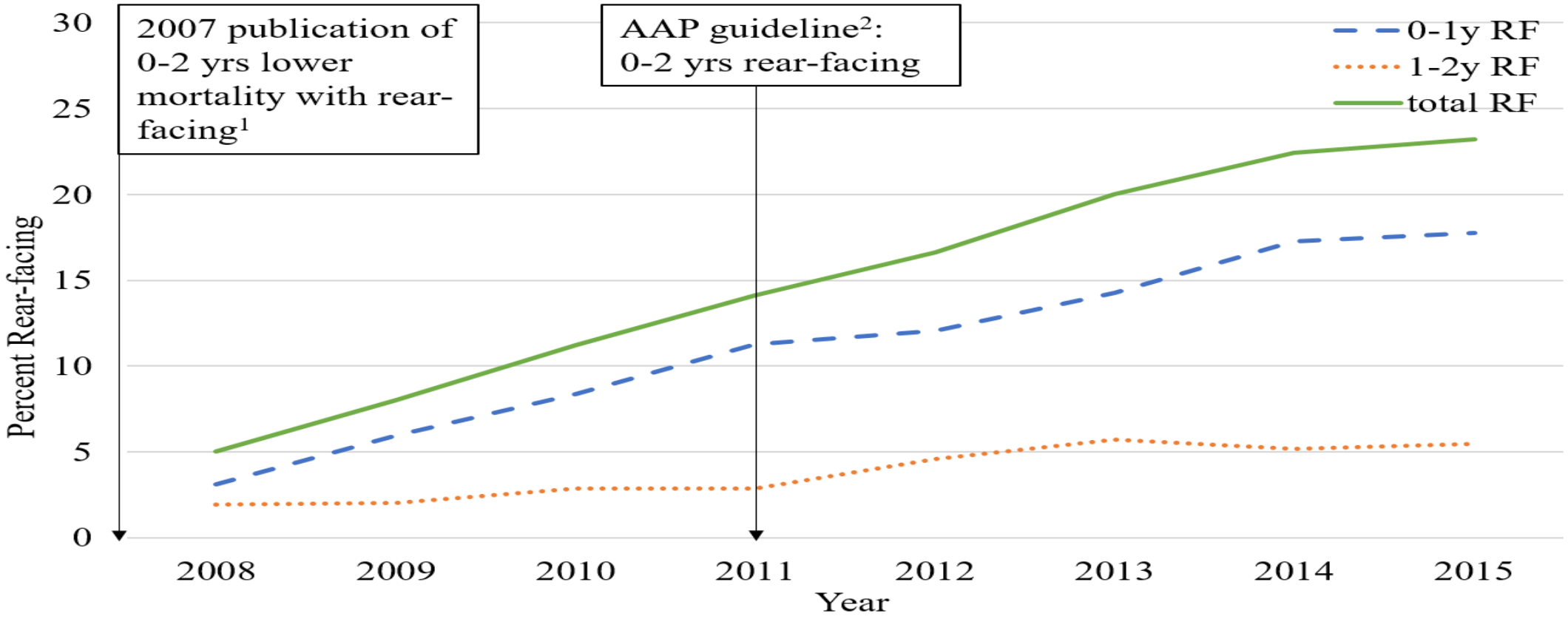
Oh, Liu and Pressley, 2017

Stage 1: Rear-Seated Infants in Rear-Facing Child Restraints

- Mortality was 3 times higher for unrestrained (40%) versus restrained (13.7%) ($p < .0001$)
- Approximately 85% of infants and toddlers were restrained in a child restraint system
- Rear-facing guideline compliance increased from 5.0% to 23.2% between 2008 and 2015 ($P<0.0001$)
- The odds of rear-facing restraint post-AAP 2011 guideline
  - Increased 1.97 times (95% CI 1.03-3.79) for infants aged 0-1
  - Unchanged for toddlers aged 1-2 years

Huang YY, Liu C and Pressley JC, Injury Epidemiology 2019 (in press)

Trends in Rear Facing Restraint for Infants Involved in Fatal Collision by Age, FARS 2008- 2015 (n=4,996)[3]



[3] Huang YY, Chang L, Pressley JC. Restraint use and injury in infants and toddlers involved in a fatal motor vehicle crash. Injury Epidemiology 2019 (in press)

Restraint Use and Injury in Private Vehicles Compared to Taxis: An Academic and NY State Health Department Collaboration

Use of CODES Data Linkages to Compare Pediatric Taxi and Private Vehicle Occupant Restraint Use and Injury in NYC

- In New York City (NYC), more than 2 million resident children and teens, and countless similarly-aged visitors, are covered by restraint laws that have several gaps:
  - Children and teens are exempt from restraint use when riding in taxis and other vehicles for hire
  - Persons aged 16 and older are not covered by rear-seat restraint laws except when riding with a GDL driver
  - Children and teens aged less than 16 years old are required to be restrained when riding in private passenger vehicles
    - Church vans are exempt

Methods

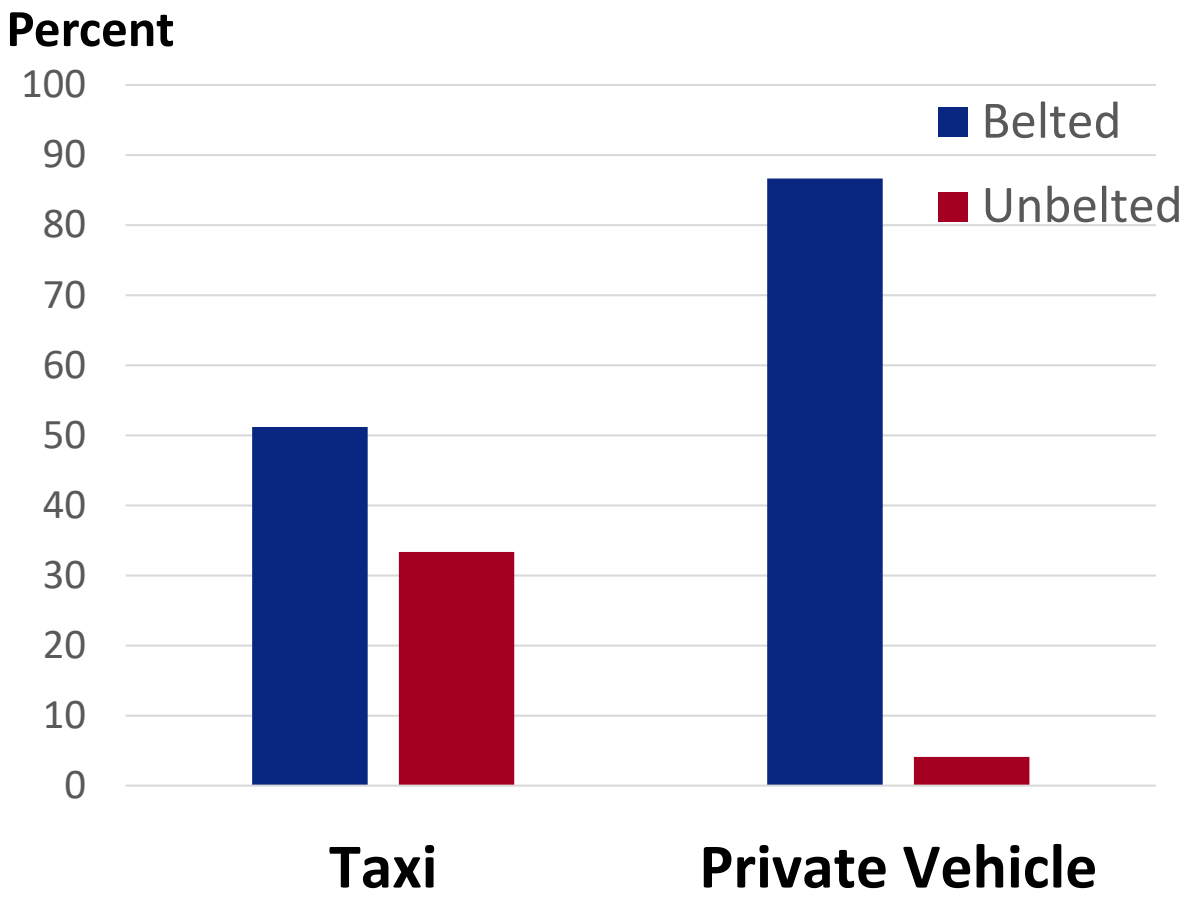
Study Population

- Rear seated passengers aged 0-19 years
- Involved in a motor vehicle crash in one of the five NYC counties from 2011-2013
- Traveling in a vehicle with registration code categorized as a taxi (n=1,631) or private passenger vehicle (n=19,053)

Data

- Crash Outcome Data Evaluation System (CODES)
- Originally developed by Highway Traffic Safety Administration as a component of its State Data Program
- Uses probabilistic methodology to link crash records to injury outcome records
- Emergency department data, hospital admissions, trauma registry data, crash reports – police & motorist reported, drivers license information and citation/violation data

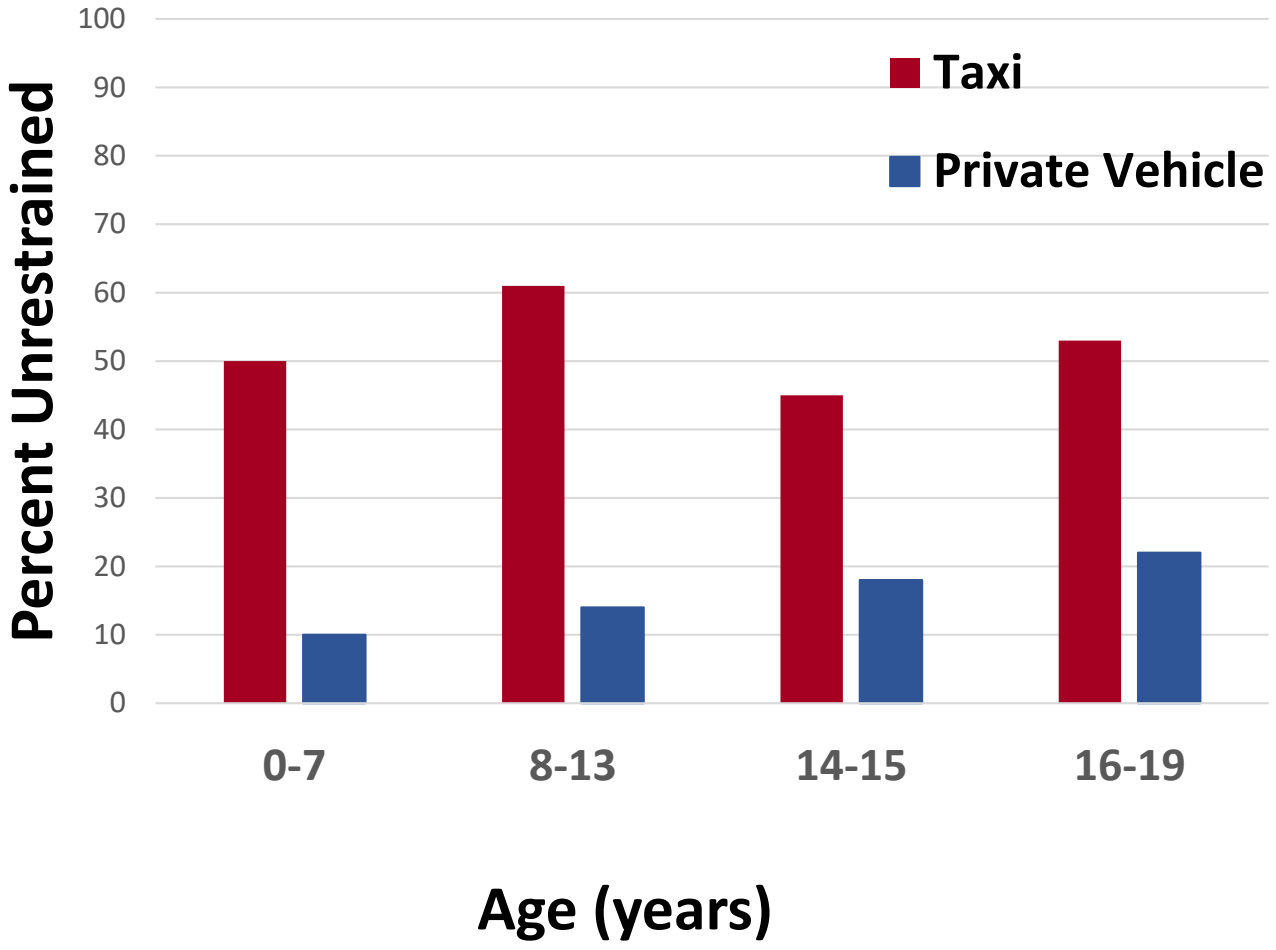
Percent Restrained in Taxis vs. Private Vehicles



Restraint use in 0-19 year old rear-seated passengers

- Significantly higher (P < 0.0001) in private vehicles compared taxis
  - 86.7% Private vehicles
  - 51.2% Taxis
- Missing data on restraint use was higher in taxis

Unrestrained Rear-Seated Passengers 0-19 years old Involved in a Crash, NYC



In taxis, approximately 50% under age 8 years were unrestrained

- **Fewer than 6% were restrained in an infant, child or booster seat**

Registration status was used to determine private vehicle

Restraint use was more frequently missing in passengers traveling in taxis

Adjusted Odds Ratio (OR) for Restraint Use in Passengers Aged 0-19 Years

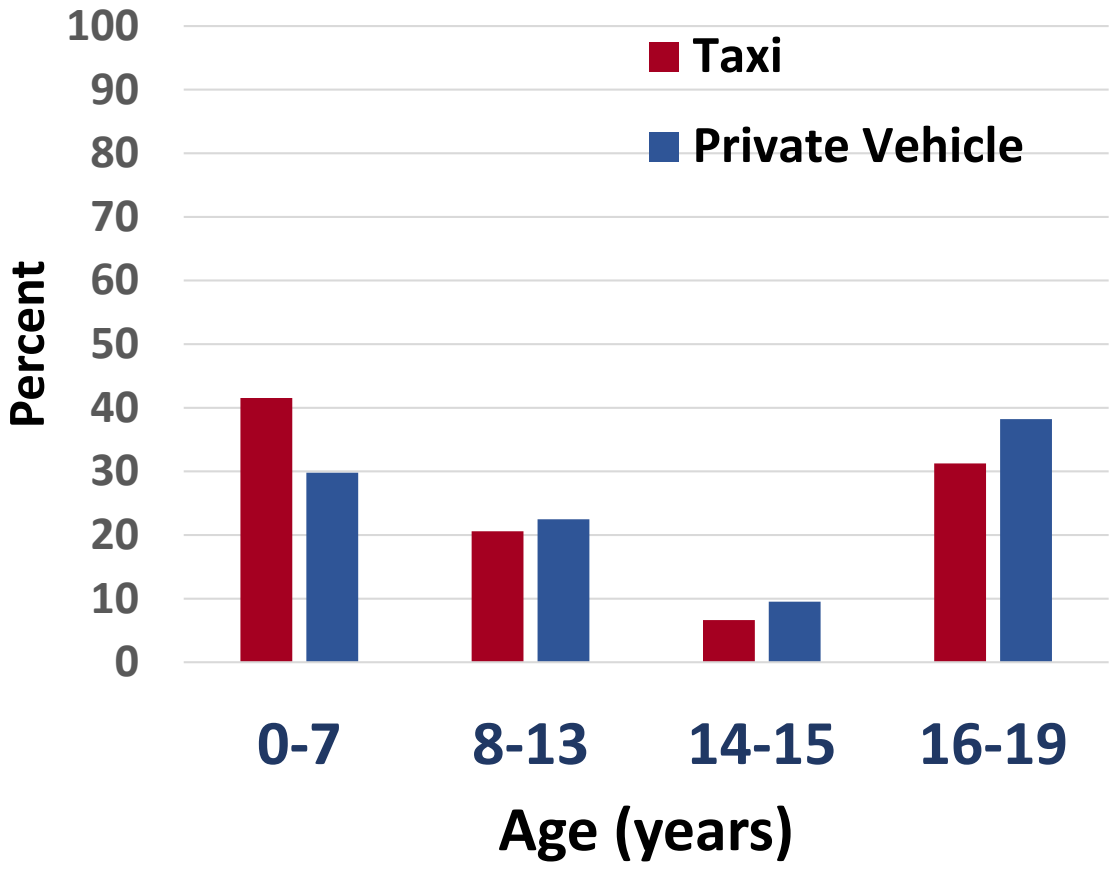
Strongest predictors of restraint use for passengers aged 0-19 years were:

- Driver belt status
- Private vehicle

Other significant predictors of passenger restraint use in the multivariable adjusted models included:

- Older driver age
- Female driver
- Younger passenger age
- Outward seating position (left or right)
- Crash occurring in one of 4 counties outside of Manhattan
- Daytime crash
- Fewer than four passengers in the vehicle

Crash Injury in Rear-Seated Unbelted Passengers by Age Group

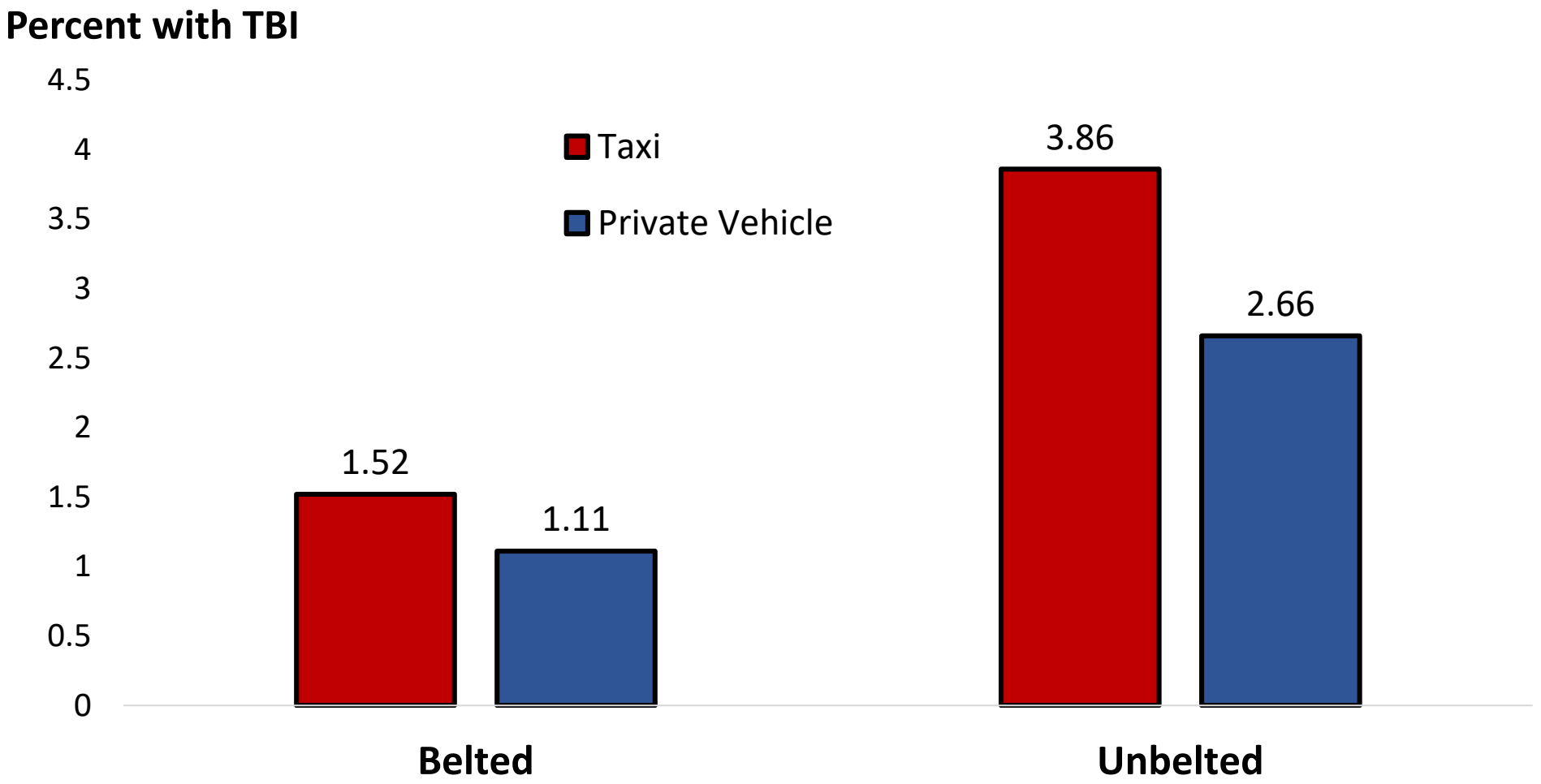


Unbelted passengers aged 0-7 years were more likely to be injured in a taxi than unbelted similarly aged children traveling in a private vehicle

Compared to private vehicles, taxi passengers were:

- Twice as likely to experience facial injury
- Twice as likely to receive diagnosis of traumatic brain injury

Percent of Crashes with Traumatic Brain Injury (TBI) by Belt Status for Private Passenger Vehicles and Taxis



Transportation Research Record, 2019 (In press)

Current Issues, Future Directions and Implications

There are several important current challenges to pediatric occupant safety unless successfully addressed

- Likely to be carried forward and continue to be issues as vehicle automation advances
- Trends in race, ethnic, socioeconomic and non-metro disparities in pediatric MV injury continues
    - Special geographic jurisdictions (IL) have low restraint use, placing their pediatric populations at increased risk
    - Primary laws are associated with higher restraint use. States with secondary restraint laws have lower restraint use

Current and Emerging Issues, Future Directions and Implications

- Changing drug laws, particularly legalization of nonmedicinal cannabis
  - Lower proper seating and restraint use in pediatric populations driven by drug, alcohol or polysubstance positive drivers
  - Alcohol and drug use in drivers of pediatric passengers is associated with increased child endangerment (front seating and lower restraint use)
- Scientific obstacles to road side testing and lack of standards for “under the influence”
  - Newly evolving drugs aimed at escaping screening detection
  - Many drugs that need to be tested do not have “road side” technology
  - Not a clear dose-response relationship between positive test and driving impairment

Future Directions: Emerging Issues With Child Motor Vehicle Safety Implications

- There are several emerging social and legal changes that have potential to impact road safety of pediatric passengers
- Examples of issues associated with the rapid growth of ride sharing and electronically hailed vehicles for hire include:
    - Taxi's and vehicles for hire are generally exempt from rear seatbelt laws– including for infants, children, teens
    - Multipurpose vehicles that crossover from use as a private vs. vehicle for hire (Ubers/Lyft/Ride hailing services) are on the rise
    - Current data systems based on vehicle registrations do not accurately capture when a vehicle was in "for hire" mode or in private use
    - Driver training and licensing is required for known vehicles for hire, but frequently not for cross over vehicles

Current and Emerging Issues, Future Directions and Implications

- Challenges in equipment/terminology harmonization
- Seat-vehicle compatibility, ease of use and behavioral responses
  - Solutions are currently being discussed as part of continuing "Moving the needle: Advancing pediatric passenger safety"
  - July 2019 meeting in DC
- The strong association between driver belt status and pediatric restraint use represents a missed opportunity to improve pediatric restraint use in many jurisdictions

Moving the Needle: Advancing Pediatric Passenger Safety

An Invitation to join future meetings and ongoing discussions

Representatives from lead governmental organizations, vehicle manufacturers, car seat component manufacturers, vehicle-for-hire companies and academics met in January 2019

- Around a single table using the format of the TRB Annual Meeting Preconference Human Factors Workshop– current and emerging issues in child occupant safety were examined:
  - Surveillance data, gaps in policy and laws and biomechanics
  - Pediatric occupant safety message-- content, behavior and delivery mechanism(s)
  - Message expansion “Birth to Fifteen”
    - Captures higher risk older child ages
  - Discussed pros and cons of early adoption of the Four Stages of Child Passenger Safety
    - Stage 1: Rear-facing infant seats for as long as child fits
    - Stage 2: Forward-facing child car seats
    - Stage 3: Booster seats for proper belt positioning
    - Stage 4: Seat belts
- Education beginning in hospital with new mothers
  - Briefly list 4 stages with statement, “Birth to Fifteen, You are at stage 1 of 4”
- Discussion will continue in July in another DC meeting

Acknowledgements and Contact Information

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- Laura Dunn, NHTSA
- Cindy Rogers and Rebecca Willmer, Webinar Support
- Bernardo Kleiner, Transportation Research Board
- Attendees and organizers of the TRB Workshop “Moving the Needle: Advancing Infant and Child Occupant Safety”

- **Contact for further information:**
- **Joyce Pressley, PhD, MPH (jp376@cumc.columbia.edu)**

PEDIATRIC BIOMECHANICS – WHAT'S NEXT

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Children's Hospital of Philadelphia™

Center for Injury Research and Prevention
The Children's Hospital of Philadelphia Research Institute

Dedicated to advancing the safety of children, youth and young adults through research and action.

Injury Research Priorities:

- Child Road Traffic Safety
- Young Driver Safety
- Pediatric Biomechanics
- Post-injury Care & Recovery
- Strengthening Communities to Prevent Injury/Promote Health
- Injury Research Methods

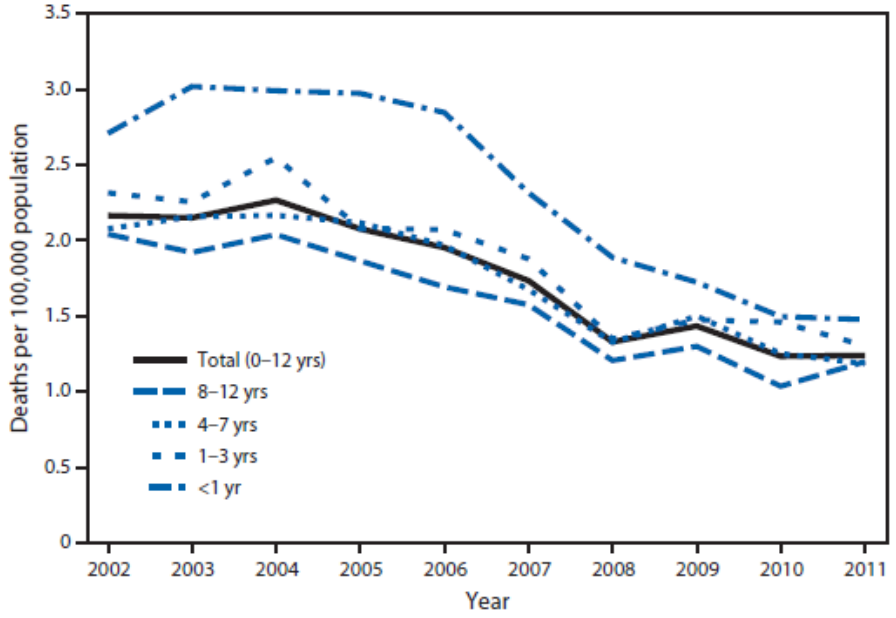
PROBLEM FACING OUR YOUTH WORLDWIDE
LEADING CAUSES OF DEATH BY AGE GROUP

< 1year	1-4 years	5-14 years	15-29 years
Preterm birth complications	Malaria	Road Injury	Road Injury
Lower respiratory infections	Lower respiratory infections	HIV/AIDS	Interpersonal violence
Neonatal encephalopathy	Diarrheal diseases	Diarrheal diseases	Self-harm
Neonatal sepsis	Malnutrition	Lower respiratory infections	HIV/AIDS
Diarrheal diseases	HIV/AIDS	Malaria	Tuberculosis
Congenital anomalies	Drowning	Drowning	Drowning
Malaria	Meningitis	Typhoid fevers	Malaria
Meningitis	Road Injury	Meningitis	Lower respiratory infections
Malnutrition	Measles	Congenital anomalies	Mechanical forces
Syphilis	Fire	Forces of nature	Diarrheal diseases

World Bank, Transport for Health: The Global Burden of Disease from Motorized Transport, 2014

US MOTOR VEHICLE DEATHS AMONG CHILDREN AGE 12 AND UNDER DECREASED BY 43% IN THE PAST DECADE

FIGURE 1. Motor vehicle occupant deaths per 100,000 population for children aged 0–12 years, by age group and year — United States, 2002–2011

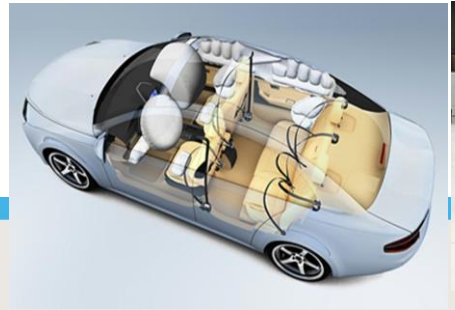


CDC Feb 2014

Increased restraint use

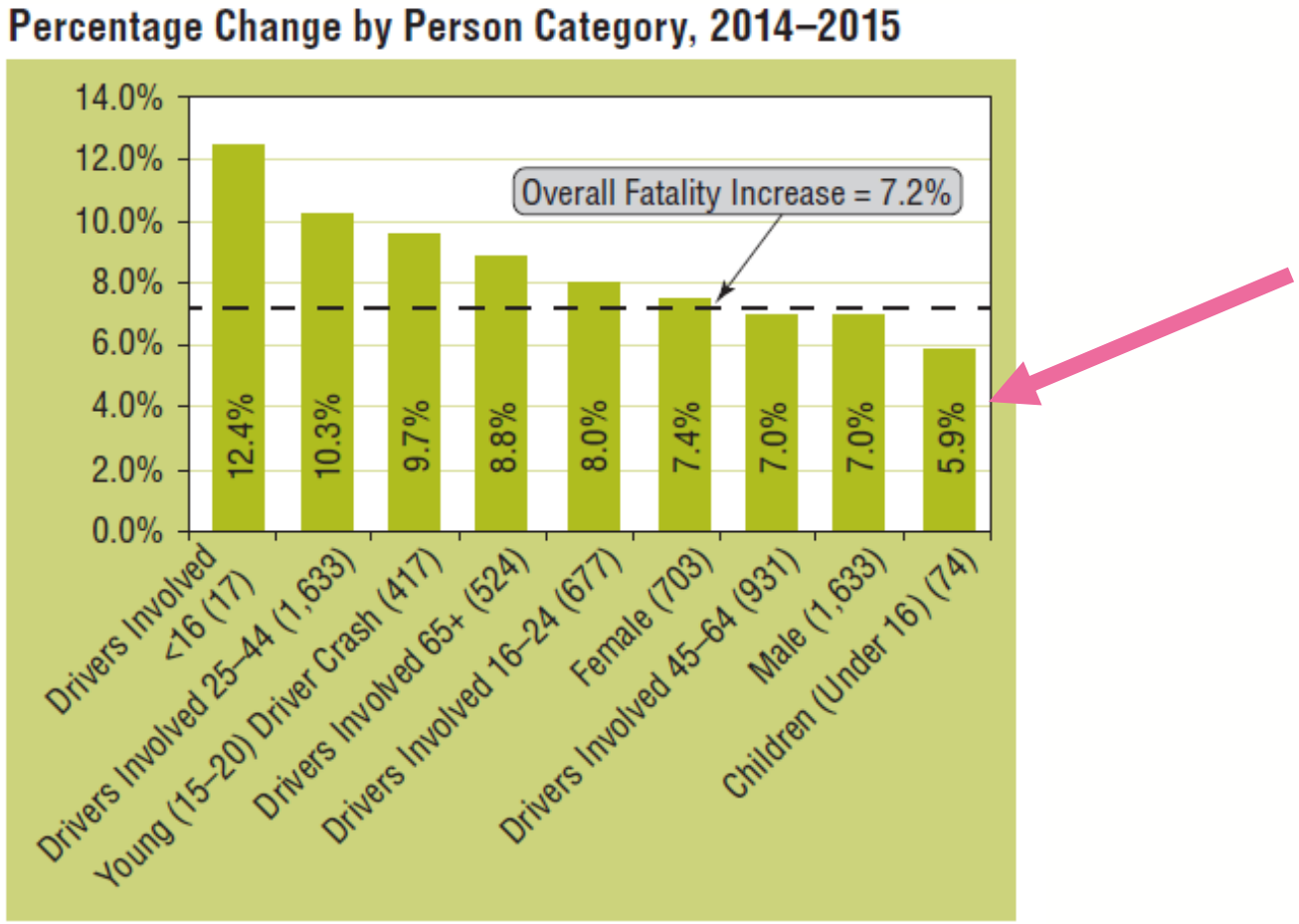
Highway safety laws

Advanced restraint systems



Vehicle Crashworthiness

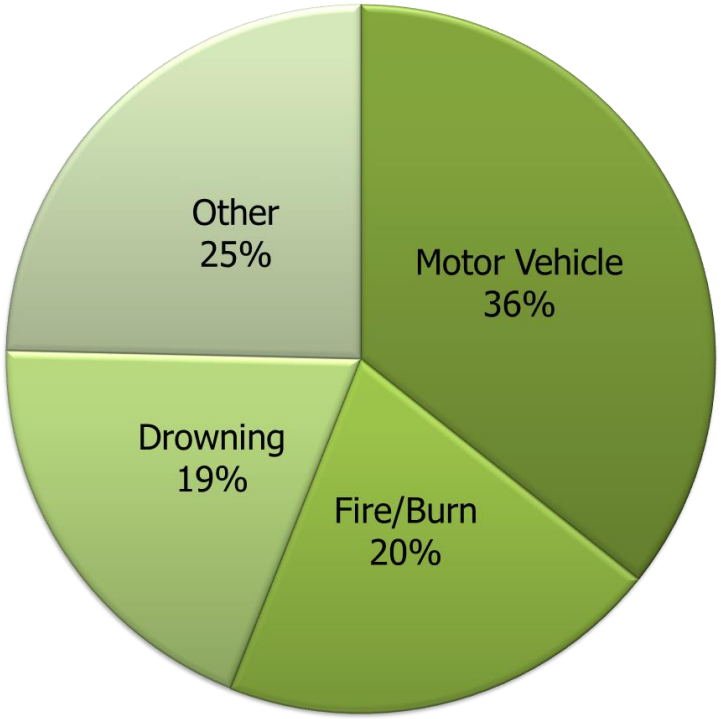
FATALITIES ARE INCREASING



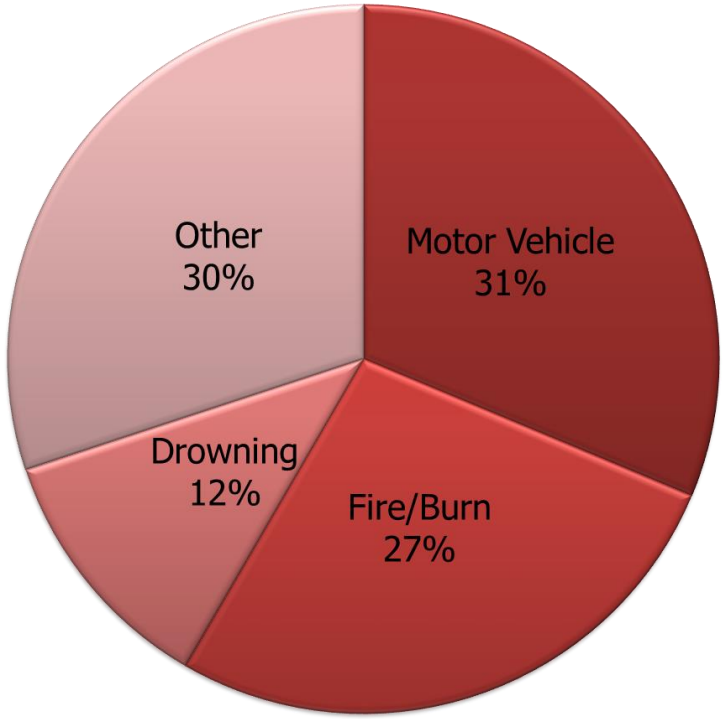
Source: FARS 2014 Final File, 2015 ARF

Pediatric Motor Vehicle Deaths
The Past 30 Years

Fatal Injury in United States (1981)
Ages 1-8 Yrs



Fatal Injury in United States (2010)
Ages 1-8 Years



Total fatal injuries has decreased, but distribution remains

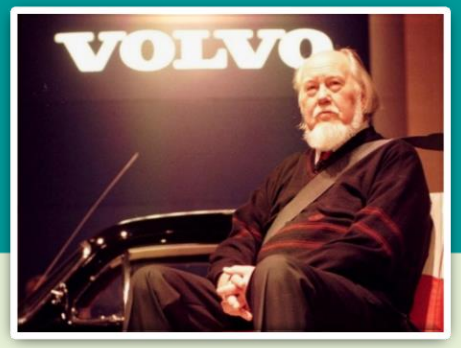
Child motor vehicle injury still a significant problem!

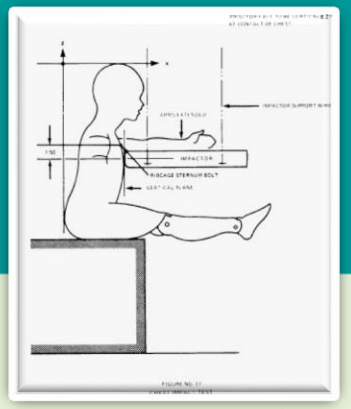
Pioneer of Automotive Safety
Col. John Paul Stapp, MD, PhD

- Human deceleration experiments using rocket sled ("Gee Whiz")
- 632 mph to 0 in 1.4 seconds
  - Experienced 46.2 *g*s

First Child Restraints

The Center *for* Injury Research *and* Prevention
at The Children's Hospital *of* Philadelphia





'40's-'50's
- Car safety features
- NOT child safety

'60's
- Seat belt
- 1st CRS
- ATD's
- NHTSA
- Testing

'70's
- CRS Regulations
- CRS Laws

The Center for Injury Research and Prevention at The Children's Hospital of Philadelphia

Occupant Injury Mechanisms -Stages in a Car Crash

Typical crash consists of 3 sub-crashes:

- 1st Collision – "Crash Dynamics"
  - Vehicle impacts object (car, tree, etc.)
- 2nd Collision – "Occupant Kinematics"
  - Occupant impacts vehicle structure
- 3rd Collision – "Impact Biomechanics"
  - Internal organ movement and damage

First collision
Crash dynamics

2nd Collision – Occupant Kinematics

- Occupant interacts with vehicle
- Severity determined by:
  - 1st Collision (crumple zone)
  - Initial position
    - Seat location
    - Pre-impact movement
  - Vehicle Interior

Newton's Law: Object will remain in motion until stopped

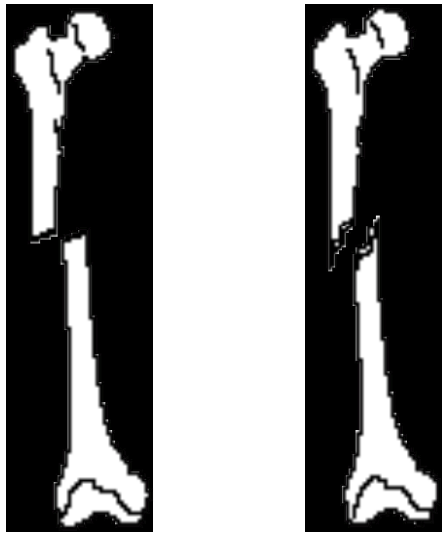
Newton's Law in Action

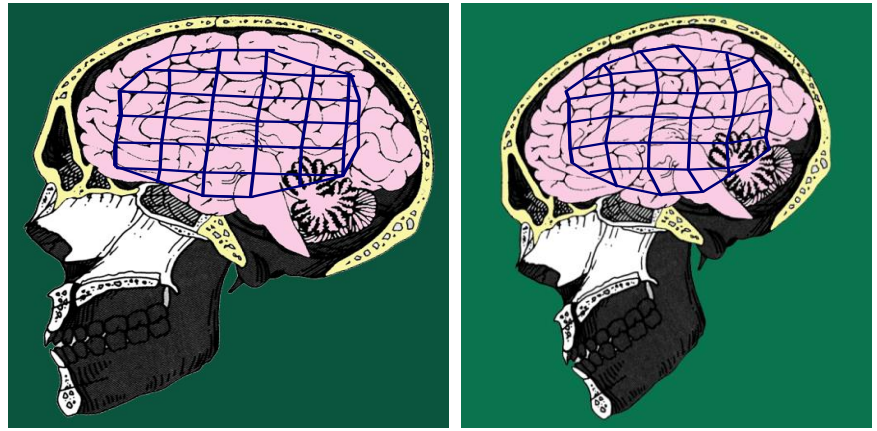
Unrestrained Children

Restrained Occupant

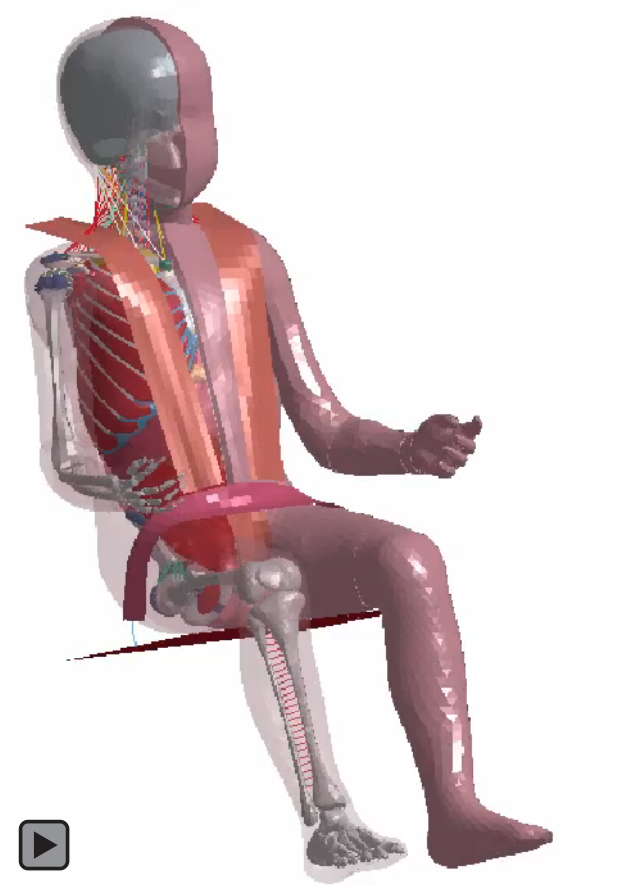
3rd Collision – Injury Biomechanics

- Organ and tissue damage
  - Direct (penetration)
  - Indirect (organ motion)
- Severity determined by:
  - Magnitude
  - How force is applied
    - Compress, bend, twist, etc.
  - Surface area
  - Rate

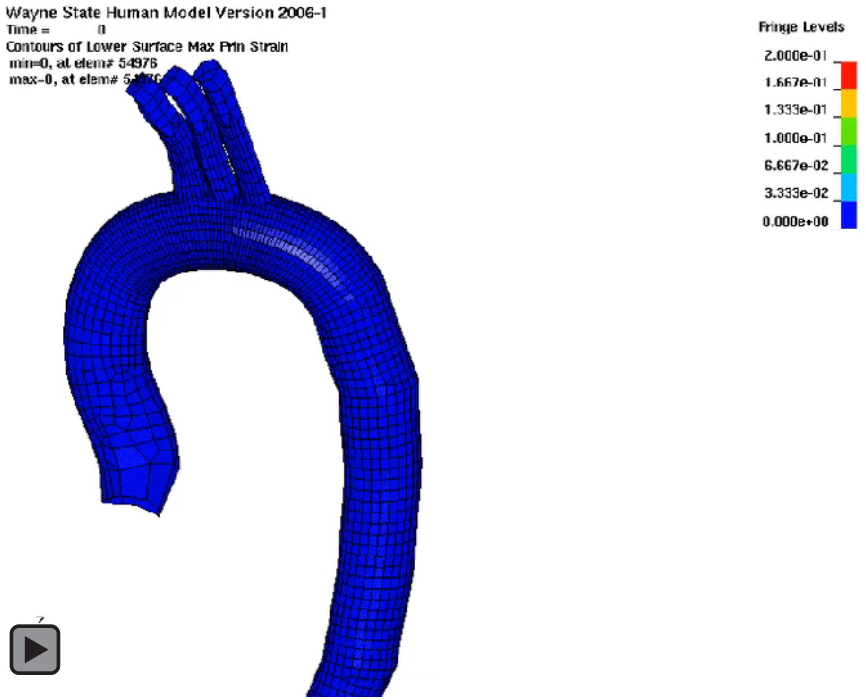




Human Body Simulations



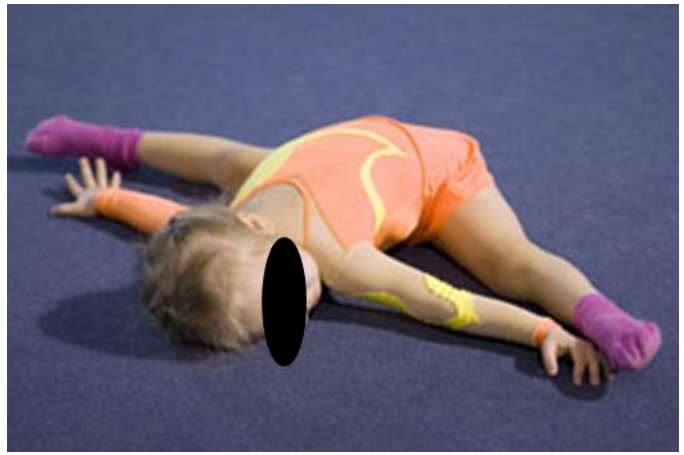
Computational Modeling of Organs



Research Question

- How different is the motion of children vs. adults in car crashes?

Children Demonstrate Substantial Flexibility



Photos courtesy of colleagues

What changes with age?

- Size
- Anatomy
  - Skeletal structure
- Material properties
  - Ligament laxity
  - Bone rigidity
- Physiological outcomes
  - Flexibility

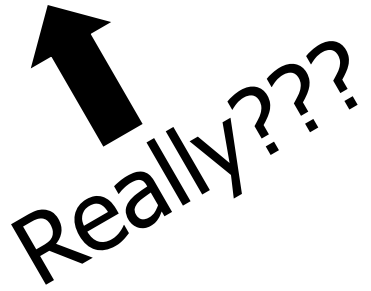
Ideal Pediatric Dummy

Ideal tool should:

- **LOOK/FEEL** like human child
  - Mass, body segment lengths, tissue properties
- **MOVE** like human child
  - Overall motion should mimic children
- **PREDICT INJURY**
  - Predict injuries observed in field
  - Age-specific injuries
  - Diverse types of injuries (skeletal & soft tissue)

Potential Automotive Research Methods for Children

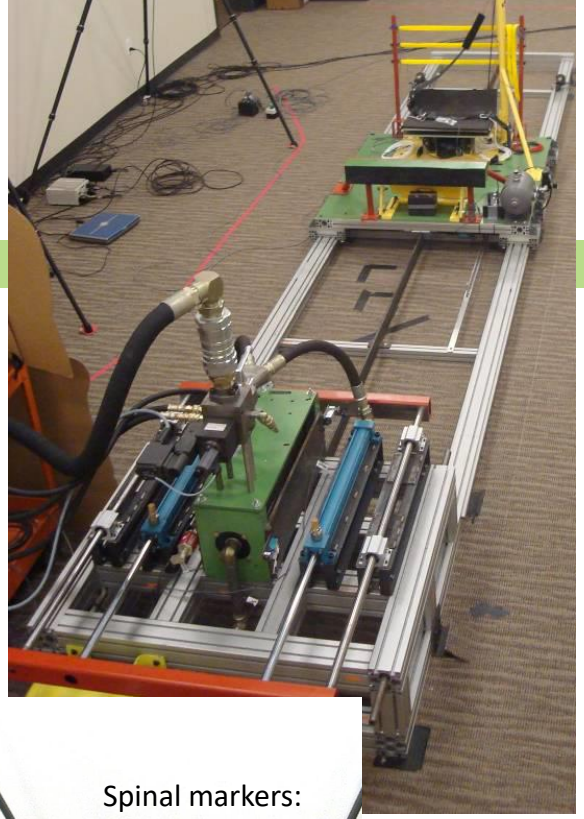
- ~~Crash Tests with PMHS (cadavers)~~
  - ~~Thankfully, no specimens~~
- ~~Animal Studies~~
  - ~~Age equivalency (6 month old pig = ? year old child)~~
- Human volunteer tests

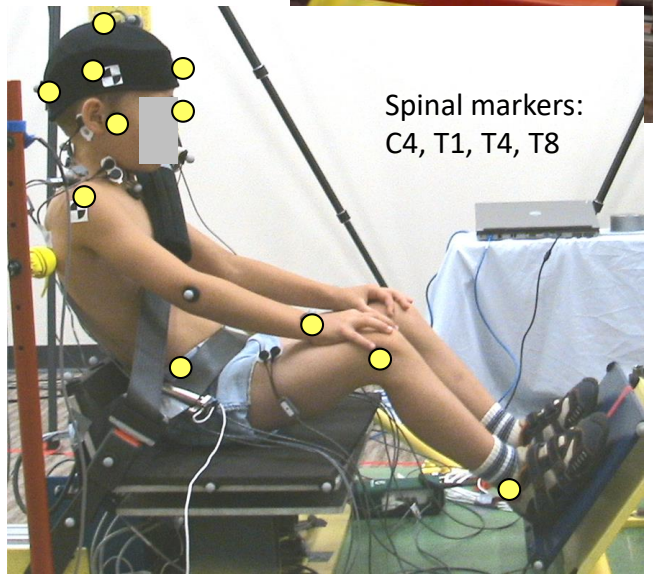


Safe Child Crash Tests???

Dynamic Response

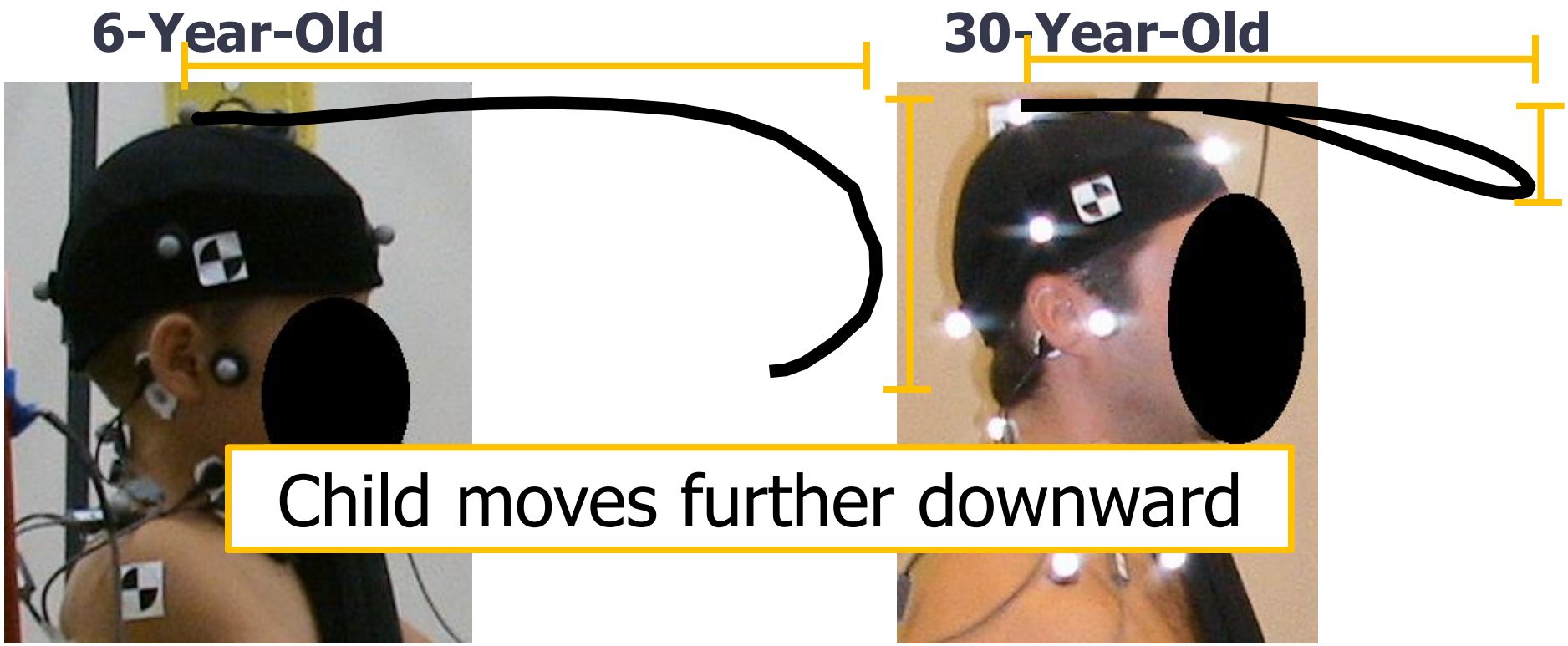
- Low speed human volunteer crash sled
- Pneumatically driven, hydraulically controlled
- "Crash" similar to that of an amusement park bumper car
- Study motion/ kinematics of children 6-14 – compared to adults





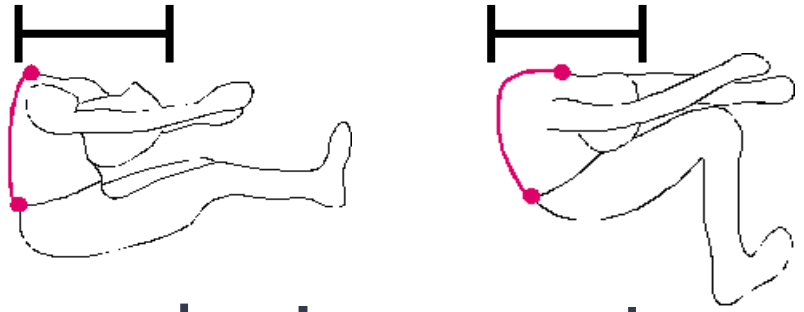
Arbogast et al, Stapp 2009

Head Top Motion Comparison



Disclaimer – Dummies are NOT Bad

- Predict forward head motion well
  - Head is primary concern for children
  - Different mechanism, but same result



- All devices can be improved
  - Accurately predict other injuries
  - Use for other impact directions and severities


Research-driven change
for safer roads

Where does safety stand today

What's Next

- Highly Automated Vehicles (HAVs)
  - Unique opportunity to do CPS from ground-up
  - Ride sharing/ride hailing
  - Mobility-as-a-Service (MaaS) Model
  - Uber/Lyft

BACKGROUND ON HAVS

- Volpe National Transportation Systems Center recently completed a review of the sections
  - how to test their vehicle designs or certify their compliance, given how the Federal Motor Vehicle Safety Standards (FMVSS) are currently written

- *"Seats are arranged in a conventional manner, but occupants can spin front seats to face rearward."*

BACKGROUND

- Non-Standard Seating
- Unique Questions
  - Economics (swiveling, space, motion)
  - Ergonomics (egress, comfort)
  - Engineering Safety (biomechanics, crash, airbag placement, children/adults)

CENTER FOR CHILD INJURY PREVENTION STUDIES (CCHIPS)

- Center for Child Injury Prevention Studies (CChIPS) unique partnership includes research sites at the Children's Hospital of Philadelphia (CHOP) Research Institute and The Ohio State University (OSU).

- Founded by the National Science Foundation (NSF), our Industry Advisory Board (IAB) comprises 13 member organizations from industry, advocacy, and government agencies (https://cchips.research.chop.edu/)

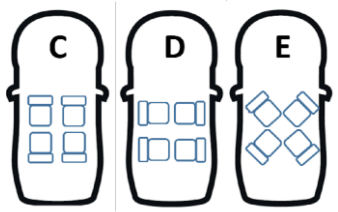
RESEARCH @ CCHIPS ON HAVS

Reaction Times in Takeover on the Driving Simulator

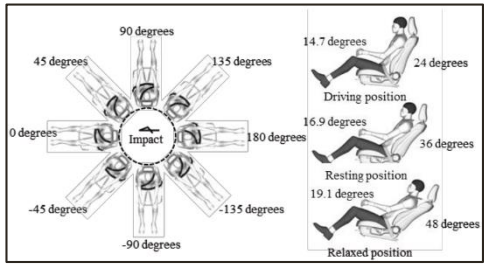
2-way road scenario	
	Autopilot fails
	Vehicles veers into oncoming traffic
	Participant needs to take over to avoid crash

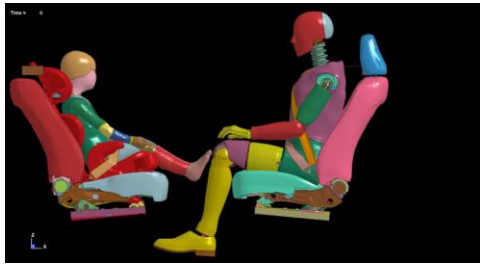
Highway scenario	
	Autopilot fails
	Car begins to drift into exit
	Participant needs to take over to avoid crash with police car blocking exit

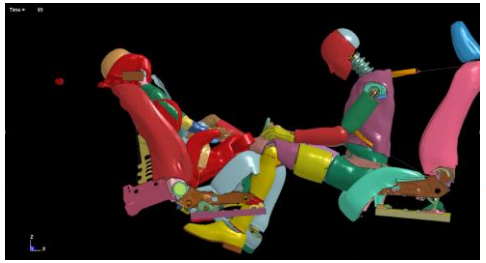
Child and Child Seat Assessment in HAV mockup



Biomechanics of Pediatric/Adult Occupants







Children's Hospital of Philadelphia RESEARCH INSTITUTE

PIs: Aditya Belwadi, PhD; Polly Tremoulet, PhD; Helen Loeb, PhD

ion Studies

Principles for successful academic-industry-consumer partnerships

- Professional obligation
  - Highest quality research
  - Present objective and accurate results
- Value honesty, fairness, collegiality, openness
- Find those partners that share mutual interest in common achievable goal

We need each other to make a difference!

Action Items

- **Stay current with the research**
  - **Injury.research.chop.edu**
    - Subscribe to *Research in Action* Blog
  - **Cchips.research.chop.edu**

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https://injury.research.chop.edu/

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TK Holdings Inc.

Toyota USA

Transportation Research Center Inc.

Volkswagen Group of America

http://cchips.research.chop.edu/

DECADE OF ACTION FOR ROAD SAFETY 2011-2020

PEDIATRIC BIOMECHANICS – WHAT'S NEXT

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Questions?

Please enter your questions in the Q & A pod

Thank you!

Please fill out our evaluation: https://www.surveymonkey.com/r/DPP2BYR

Visit our website:
www.ChildrensSafetyNetwork.org